

# RESTORING LAKE PEDDER: A GEOMORPHOLOGICAL PERSPECTIVE ON RECOVERY PROSPECTS AND LIKELY TIME SCALES

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*This paper assesses the prospects for the return of the landforms of the Lake Pedder area to their pre-flooding condition should the Huon and Serpentine Dams be drained. Restoration of Lake Pedder would not be a practical option unless those landforms that evolved in response to geomorphological processes that are no longer experienced remain intact. However, there is every reason to anticipate that they have survived essentially unscathed. Those landforms that have resulted from geomorphic processes that persist to the present day are a less troublesome proposition because any moderate-scale damage to the beach and dune systems may be naturally self-healing. However, the evidence indicates that only very minor damage occurred during filling of the dams when the water levels placed the dunes most at risk, and they have been insulated below the level of effective wave erosion since that time.*

*Erosion around the perimeter of the Huon - Serpentine Impoundment has not had any significant detrimental impact upon the key landforms that contribute to the geoscientific values of Lake Pedder and its landform community. While the public perception may be that a massive area has been devastated, erosion is confined to the perimeter of the artificial reservoir where it is akin in extent and appearance to that produced by discontinuous stretches of vehicular track. From an aesthetic perspective the terrain visible from Pedder Beach contains relatively limited areas of severe scarring. Many of the classic photographic images of Lake Pedder, focussed as they are on the beach environment, will probably be achievable again almost immediately upon draining of the dams.*

**Key Words:** Australia, Tasmania, Lake Pedder, geomorphology, geoconservation, restoration, lakeshore erosion

## INTRODUCTION

The Lake Pedder environment was never documented properly prior to construction of the Huon and Serpentine dams. Hence, the question of possible restoration of the original environment is complicated by the lack of detailed benchmarks. A companion paper in this volume (Kiernan 2001) attempts to redress some of this shortcoming from a geomorphological perspective, in an effort to belatedly provide accessible documentation of the geomorphological values at least up to the approximate level of the biological documentation provided by Bayly *et al.* (1972).

That paper documents (1) the geomorphological taxa present in the area and the processes that gave rise to them; (2) those geomorphological processes that persist under the present postglacial conditions and are significant to the potential for "self-

healing" of any landform damage caused by the flooding; (3) the potential for any sediment influxes into the original lake basin since the dams were filled and the likely nature, source and extent of sediment; and (4) the significance of Lake Pedder in terms of geoconservation and geodiversity, outlining the features of the Pedder landform community that are most critical from those perspectives.

The principal aim of the present paper is to assess, in the light of the information provided by Kiernan (2001), the prospects for the return of the critical components of the natural Lake Pedder landform community should the Huon-Serpentine hydro-electric impoundment be drained. A second aim of this paper is to review important new information obtained from beneath the reservoir by Tyler *et al.* (1993, 1996) and summarised by Tyler (2001). This evidence strongly suggests that important components of the Lake Pedder complex remain intact beneath the waters impounded by the Huon

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and Serpentine dams. Those authors concluded that:

- The geomorphological features of Lake Pedder and Lake Maria are largely intact;
- The principal original drainage channels such as the Serpentine River and Maria Creek remain intact;
- The bed and beaches of Lake Pedder still consist of the pink sand characteristic of the original lake;
- All major features of the beach and dune systems remain intact;
- Ferromanganese concretions (Pedder Pennies) remain abundant;
- Conditions remain aerobic at the lake bed;
- No more than a few millimetres of sediment has accumulated over the lake bed;
- Decomposition of vegetation over the surrounding swamps and plains is incomplete;
- Immediately recognisable remains of the original flora lie on the lake bed;
- The underlying soil remains bound by root systems;
- Recognisable remains of the original emergent macrophytes are recoverable from the Lake Maria area;
- Significant scarring has occurred around the perimeter of the artificial reservoir where small scree slopes of slumped material now exist, but the features of the original lake escaped this fate due to the rapidity with which the reservoir was filled.

Tyler *et al.* (1993, 1996) have therefore provided strong evidence that the restoration of the original lake is quite feasible. Their study involved echo soundings over the position of recorded landforms at the original lake, and sampling of the bed with a Glew gravity sediment corer and with an Eckman sediment grab. This practical demonstration that important elements of Lake Pedder remain intact warrants review in a wider context. Is the survival of the Pedder landforms consistent with other evidence and theoretical grounds, taking into account geomorphic processes in the Lake Pedder area before, during and after the flooding?

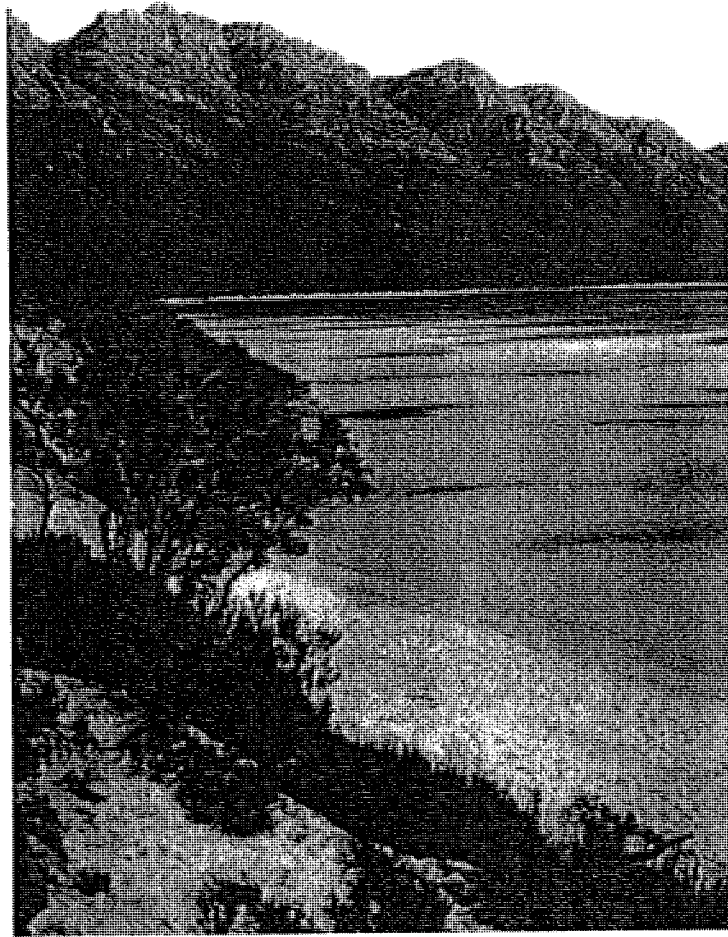
A geoconservation perspective on possible restoration of Lake Pedder must address at least four principal questions:

1. What is the likely present condition of the geomorphological phenomena?
2. What issues need to be considered during the re-exposure phase?
3. If some landforms have been damaged, to what extent will natural processes restore the damage and over what time scale?
4. To what extent may natural processes be insufficient to heal any erosion damage? Where is any such damage likely to be? How significant is it?

This paper also discusses erosion around the margin of the Huon - Serpentine Impoundment beyond the immediate environs of Lake Pedder. However, the question of this potential new fossil shoreline and its possible rehabilitation does not bear significantly on the restoration of Lake Pedder itself.

In his addendum to the report of the Lake Pedder Committee of Enquiry (LPCE 1973, p. 45) Edward St John reported that "in our view, the major issue is neither the fate nor the status of the endemic species, important though they are. It is the wilderness and recreation aspects of the area as a national park." Indeed, while the scientific values of Lake Pedder provided important reasons for not flooding the lake they came late in the debate for the vast majority of people who were opposed to the flooding and to whom the main attraction of Lake Pedder related to its aesthetic and recreational values. Examination of the photographic record of Lake Pedder emphasises the importance of the geomorphology in defining that experience, notably the beach and dune system and the mountains that rose above them. The prospects for survival and recovery of the geomorphology of the area therefore largely also implies the prospects for the return of a Lake Pedder comparable to that which most visitors experienced. Since Lake Pedder lay on the broad bottom of the Serpentine Valley, the water, the beach, the Maria Creek channel, the dunes and the mountains were virtually the only features visible to visitors once they reached the lake. The surrounding plains and lower slopes were out of sight.

The assessment provided in this paper is based primarily on current understanding of how the geomorphology of the Pedder area evolved; observations regarding the response of critical landforms during filling of the dams; insights provided by inspections of other hydro-electric storages at times of low water level when the



**Figure 1:** Some key elements of the Lake Pedder landscape: the seasonally exposed lake bed; the beach; the naturally-eroded windward western face of the dune mass, and, in the background, the gentle slopes at the foot of the Frankland Range (photo: K. Kiernan).

drowned landforms on their beds could be examined directly; and insights provided by recent data obtained from the site of the natural Lake Pedder by Tyler *et al.* (1993, 1996). A preliminary assessment of erosion around the perimeter of the Huon - Serpentine Impoundment was also undertaken, involving field inspections of parts of the perimeter coupled with air and ground photo interpretation.

#### THE LIKELY PRESENT CONDITION OF THE LAKE PEDDER LANDFORM COMPLEX

The critical landform, Lake Pedder itself, consists of a number of closely integrated elements (Kiernan 2001). Principal among these are the lake depression itself and the glacial sediments that form its downvalley margin, the constricted outlet to the Serpentine River, and the water within the lake basin with its distinctive burgundy colour, imparted by organic leachates from the surrounding area. Nested within this broad basin are the other

features that added to the scientific importance of Lake Pedder and for many gave the area its principal appeal: the sand bed; the bar and mega-ripples; small scale ripple bedforms; Pedder Pennies; the beach; and the dunes (Figure 1). From a geomorphological viewpoint the restoration of Lake Pedder cannot be considered a practical possibility unless these elements either: (1) remain intact or, (2) if they are damaged, have the capacity to regenerate either naturally or with assistance; and (3) are not at risk of serious damage as a consequence of draining the dams following two and a half decades of inundation since the Huon and Serpentine dams were filled. The Lake Pedder landform community additionally comprises other genetically-related landforms such as the glacial phenomena that extend from the slopes of the Frankland Range and across the floor of the Serpentine River Valley, and various fluvial channels including the meandering Serpentine River and braided Maria Creek channels (Johnson 1972, Timms 1992, Kiernan 2001).

### *The Lake Pedder basin*

The natural Lake Pedder is contained to the east by the upvalley gradient of the Serpentine River drainage system, and to the west by a barrage of glacial sediment. The natural Lake Pedder is ~1.5m deep under summer conditions, with a trench ~3m deep in the south-eastern corner of the lake (Tyler *et al.* 1993, 1996). The basin is a fossil feature, produced by glacial and other processes that were active under climatic conditions different to those that presently exist (Davies 1967, Peterson 1969, Timms 1992, Kiernan 2001). Hence, whether the basin has survived is critical because if it has been destroyed it would not be able to regenerate naturally when the dams are drained (although any relatively minor breaches of the basin perimeter could doubtless be repaired using earthmoving equipment if necessary).

What potential exists for the lake basin to have been modified either by erosion or through infill by sediment? On first principles, there is no reason to suppose that this basin should have been modified to any significant extent by erosional processes subsequent to construction of the dam, either as the dams filled or over the years the impoundment has been full. The critical features mostly lie at least 15m below the surface of the impoundment. The potential for erosion of the lake bed by waves is limited by the scale and origin of the waves. Waves consist of orbital movements of water that diminish rapidly in size until motion is very limited at a depth equivalent to half the wave length (Bird 1972). With the steep choppy wind waves that characterise the impoundment the effective depth for erosion is probably limited to no more than ~3-4 m even under the most extreme of conditions. Given that the present lake level is ~15m above the level of the natural lake, and is held within a range of 1.5m by statute, it is difficult to envisage erosion of the natural basin floor.

The barrage of glacial sediments at the downstream end of the lake is kilometres broad and is robust: by analogy with the evidence for only limited sublacustrine erosion elsewhere, there is no likelihood whatsoever of its having been breached as a result of sublacustrine erosion. Similarly, the Serpentine River outlet should be relatively robust given the bank materials in that area, the low gradient of the valley floor and the lack of any source for strong bottom currents, which are likely to be largely restricted to denser flows of cold snowmelt that may hug the floor of the impoundment in winter. Tyler *et al.* (1993, 1996) have demonstrated that the outlet persists after two decades of inundation and there seems nothing improbable in this situation from geomorphological first principles.

Infilling of the basin by sediment would demand a sedimentation rate sufficient to generate in excess of 1m of sediment over about two decades. Two possible sediment types need to be considered, namely minerogenic sediment and organic sediment. The principal minerogenic sediment source available comprises predominantly quartzitic rocks. The natural minerogenic sediment load of streams draining into Lake Pedder prior to dam construction was very low, and consisted primarily of quartzite sands and silts similar to those that form the beach.

Erosion by waves around the perimeter of the new impoundment has locally stripped the surficial sediments in steeper areas to expose the bedrock beneath. However, even on the exposed eastern shoreline south of Harlequin Hill, and the exposed southern shoreline around Scotts Peak, stripping has occurred over only a relatively narrow band usually no more than ~3 - 4m in vertical extent. The original peat cover with plant remains in growth position is intact below this level. The coarser rock materials quarried from the perimeter by waves lie scattered on these peat mats in close proximity to the sites from which they have been won. In local areas finer materials such as sands have been distributed more widely, but given the total volume removed, the length of shoreline involved and the volume of the impoundment, nowhere near enough transportable minerogenic sediment can have been generated to impact significantly on the depth of the Pedder basin. In most shallow embayments on the perimeter of the new storage the peat mat has not been disturbed by wave erosion, even in relatively exposed areas.

Organic sediment must also be considered and there are three potential sources. The first involves the possible accumulation of organic sediment washed into the impoundment from the surrounding slopes since the dams were filled. Observations on the nature of the Pedder environment indicate that very little organic sediment reached the valley floor from the surrounding slopes under natural conditions (Kiernan 2001). The surrounding slopes are well vegetated and stable with the fibrous peat mats generally very thin. Very little organic material was evident in the stream channels previously or is evident now. The peats on the slopes can effectively be discounted as a source of sufficient volumes of organic sediment to fill the basin. The second potential source of organic sediment involves reworking of the peats and other plant materials inundated beneath the artificial impoundment. The peats that occur on the lowest slopes and valley bottoms are considerably thicker than those on the higher slopes. In the poorly drained areas they consist of profiles in excess of 1m thick in which fibrous peats overlie muck peats. In broad terms the organic content of the peats

diminishes upslope as the inwashed minerogenic content increases (Pemberton 1989, 2001). For these valley floor peats to be redistributed would require the breakup of the fibrous peats to liberate the muck peats, and sufficiently strong bottom currents to transport this material. Around the storage perimeter the only place where the fibrous peats have been broken is where steep slopes are exposed to wave action, elsewhere they remain intact with no sign of simple decomposition beneath the water. The bottom of the impoundment where the muck peats are thickest is below the effective level of wave action and there is little likelihood of sufficiently strong bottom currents to, say, remove peat from the floor of the Serpentine Valley and transport it eastwards into the Pedder basin. Tyler *et al.* (1993, 1996) have demonstrated that conditions remain aerobic on the impoundment bed surrounding Lake Pedder. Even if the peat on the impoundment bed was able to be redistributed, its volume is not sufficient to cause significant infilling. Sedimentation in Tasmanian alpine lakes (minerogenic plus organic) since deglaciation typically totals little more than 100cm (Macphail 1979). Even if we assume a sediment depth of 200cm over the 10,000 - 14,000 years since deglaciation, that would still amount to only a few millimetres over two and a half decades, roughly the time since Lake Pedder was inundated.

Tyler *et al.* (1993, 1996) note that the principal source of reservoir - floor sediment in the area of the original lake is autogenic material produced by planktonic organisms, possibly supplemented by some redistribution of material resulting from decay of the original vegetation. They consider the apparent rate of accumulation over Lake Pedder to be in accord with accumulation rates of 0.5-1.0 cm/decade evident from studies of other oligotrophic lakes around the world. Webb & Webb (1988) indicate that the mean rate of accumulation for 291 North American lakes was 0.9 cm/decade while work by Cameron *et al.* (1993) indicates accumulation of  $0.55 \pm 0.07$  cm/decade in Lake Nicholls at Mt Field, Tasmania, over the last 100 years.

These considerations suggest there are simply no grounds for assuming the Pedder basin may no longer exist, or that it has been modified in any significant way. Nor does there seem any theoretical reason why any significant modification of the Serpentine outlet should have occurred. Should the dams be drained the Pedder basin would again hold a water body closely matching in every way that which it previously contained, burgundy coloured with organic leachates like the water of the original lake and indeed like that contained in the present artificial reservoir. The evidence provided by Tyler *et al.* (1993, 1996) is entirely consistent with this prognosis. This fossil landform is robust and almost certainly remains intact. No

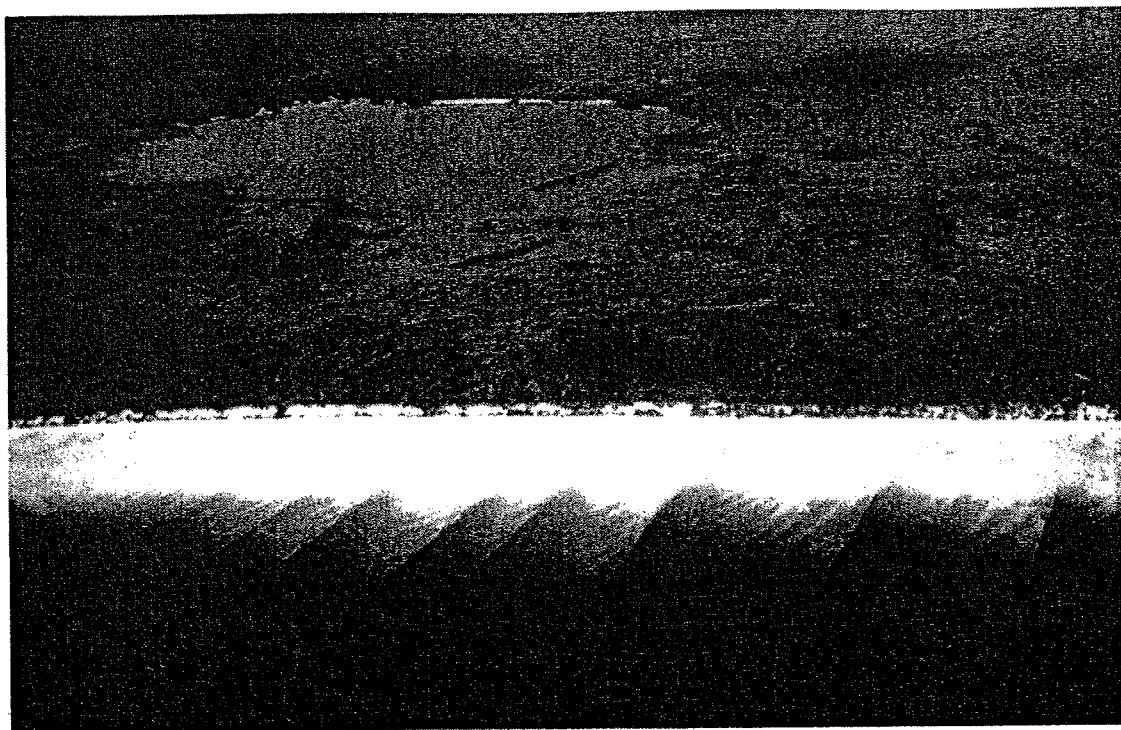
human intervention is likely to be necessary in order to restore it when the dams are drained.

#### *The nested landforms: lacustrine, fluvial, aeolian*

The sandy bed of the Lake Pedder basin can also reasonably be expected to remain intact. As previously indicated, it lies well below the level of effective wave erosion and at any rate it is probably fairly thick. The chances of it having been damaged by erosion are virtually non-existent. As indicated above, there is also little likelihood of much covering of the bed by sediment since filling of the dams. Any minerogenic sediment derived from the surrounding hills or washed in from eroding impoundment shorelines is likely to be of minimal volume. Given the distance to the lake basin from the impoundment margins, and the slope gradients, any material that did reach the basin would be of very fine calibre only. Moreover, it would consist of light coloured quartzitic material, the same material as already forms the bed of Lake Pedder and, hence, cause no change from its pre-flooding condition or appearance. For the reasons already cited, there is also no reason to anticipate much organic sedimentation that might have covered the sand bed. Tyler *et al.* (1993, 1996) have demonstrated that any organic sedimentation on the bed of the original lake must be no more than millimetres thick. For similar reasons, the bar in the natural Lake Pedder can also be expected to have remained intact.

The mega-ripples on the floor of the original lake were the product of a slow clockwise circulation of the water in the lake (Figure 2). Their termination at the margin of the bar reflects the importance both of the materials in transit, the broad topography of the lake bed, and water depth. Bottom currents might have been modified since filling of the storage, at least locally, potentially impacting on the mega-ripples. However, Tyler *et al.* (1993, 1996) have demonstrated that mega-ripples which appear broadly consistent with those in the natural lake still occur in that position beneath the much deeper waters of the artificial impoundment. The mega-ripples in the natural lake were not fossil features but were the product of contemporary postglacial processes of sand transport by circulating lake water. Hence, even if they had been destroyed totally, or if they have been damaged, they could be expected to reform rapidly within a very short span of time, probably as little as a year or two, once the original lake levels were re-established.

The highly photogenic smaller scale ripple bedforms that ornamented the pink quartzite sands of the original lake were the product of various other lake water movements including wave action,



**Figure 2:** Mega-ripples at the eastern end of Lake Pedder. Note the continuous natural erosion scarp along virtually the full length of the dune face behind the beach, and the very great breadth of the dune mass behind the foredune, reaching to the Maria Lakes system and beyond it (photo: K. Kiernan).



**Figure 3:** The Serpentine River channel during filling of the Reservoir in 1972. No evidence of riverbank collapse is evident, nor any evidence of trees being torn down by waves and the banks levered apart as the water rose. This is consistent with evidence gained during inspection of older artificial reservoirs when drawdown has exposed their floors to reveal intact streambanks with dead trees or stumps still in growth position upon them (photo: K. Kiernan).

streamwater flows and beach springs. Some modification of these since filling of the dams is to be anticipated, but such features are transient by their very nature. Those on Pedder beach were not fossil features but were the product of seasonal changes and day-to-day weather events. They would reform rapidly following draining of the dams. Natural forms would progressively come to dominate the suite of bedforms again as soon as the lake waters regained their natural level. Underwater video footage obtained in 1994 and shown on ABC television has revealed that the tyre tracks of light aircraft that landed on the exposed sand bar prior to the dams filling still remained visible more than two decades later. Hence, even small scale sand ripples on the beach may well have survived.

The distinctive ferro-manganese encrustations known as Pedder Pennies, well known to those who visited the original Lake Pedder, appear to be mature forms of incipient encrustations that occur in the Maria Lakes. There is no evidence of their ongoing genesis in Lake Pedder itself (Tyler 1979, Tyler & Buckney 1980). They might therefore be regarded as fossil features, even if relatively recently so. Hence they may be a potentially vulnerable component of the Pedder complex. However, there is little theoretical reason why they should have been swept away by bottom currents, indeed their discoidal shape is a hydrodynamically poor one with respect to their potential transportation by low energy water flows. Similarly, for the reasons already cited, there is little reason to anticipate their burial by sediment. Tyler *et al.* (1993, 1996) have demonstrated unequivocally that Pedder Pennies remain abundant beneath the Huon-Serpentine Impoundment on those parts of the original lake bed where they were most abundant prior to filling of the dams, and that negligible sediment has accumulated there.

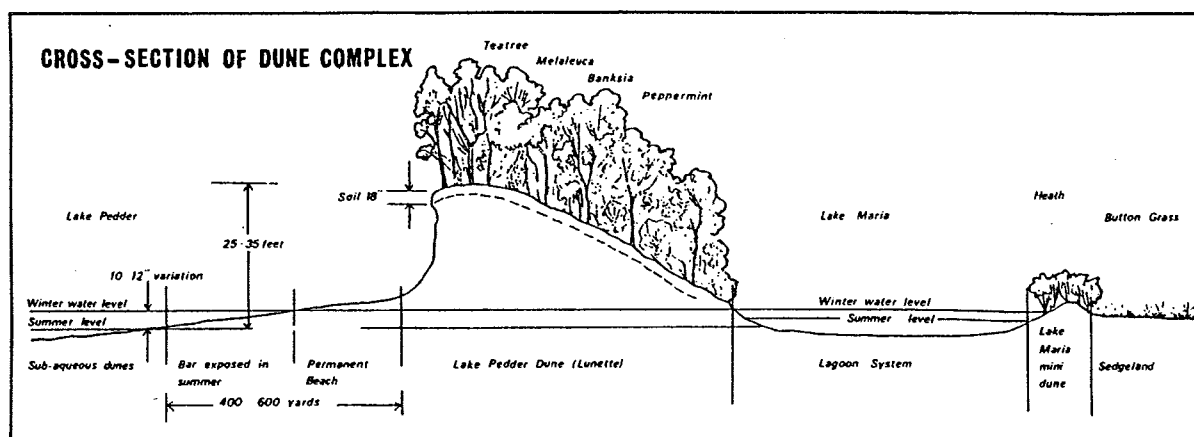
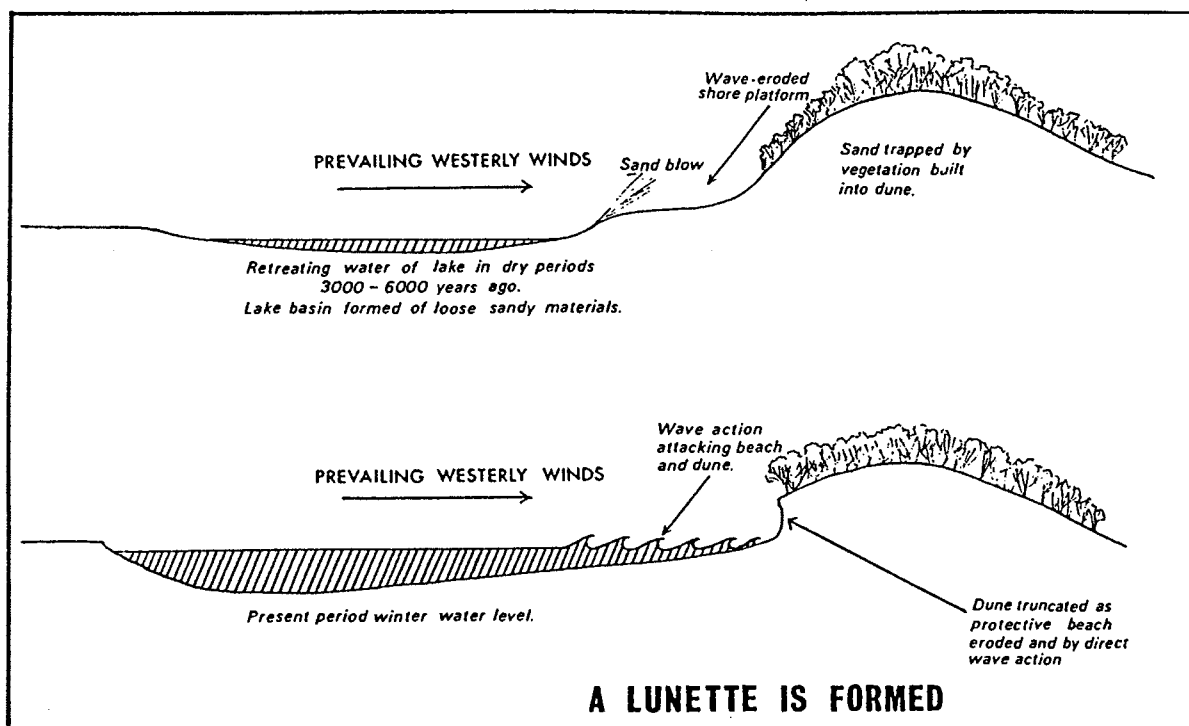
The permanent Pedder Beach lay on the windward side of the Pedder lunette north of Maria Creek. Given the intact condition of the other original features on the floor of the Pedder basin, including even the megaripples, there is little reason to anticipate any significant damage to the beach.

The most dangerous period for all the Pedder landforms was as the dams were filling (Figure 3). During the filling process the water began to impinge higher on slope profiles than was naturally the case and water depth was sufficiently shallow for potential erosion of lakeside landforms by waves. Under these conditions some accelerated removal of sand from the already naturally truncated windward face of the lunette system was observed. This seemed alarming to lay bushwalkers at the time but needs to be considered more analytically and in context with geomorphological processes and the natural erosion

of the dune face that occurred each winter. Any material eroded from the dune face would have been drawn back onto the beach, potentially steepening the beach profile slightly. However, given the limited amount of sand removed in this manner, any such modification can only have been slight as the survival of aircraft tracks on the beach emphasises. Given also that the lunette was naturally formed by sand blown from the beach and bar by winds under similar Holocene climatic and hydrological circumstances as persist today, the natural beach profile can be expected to re-establish rapidly once natural lake levels are re-established.

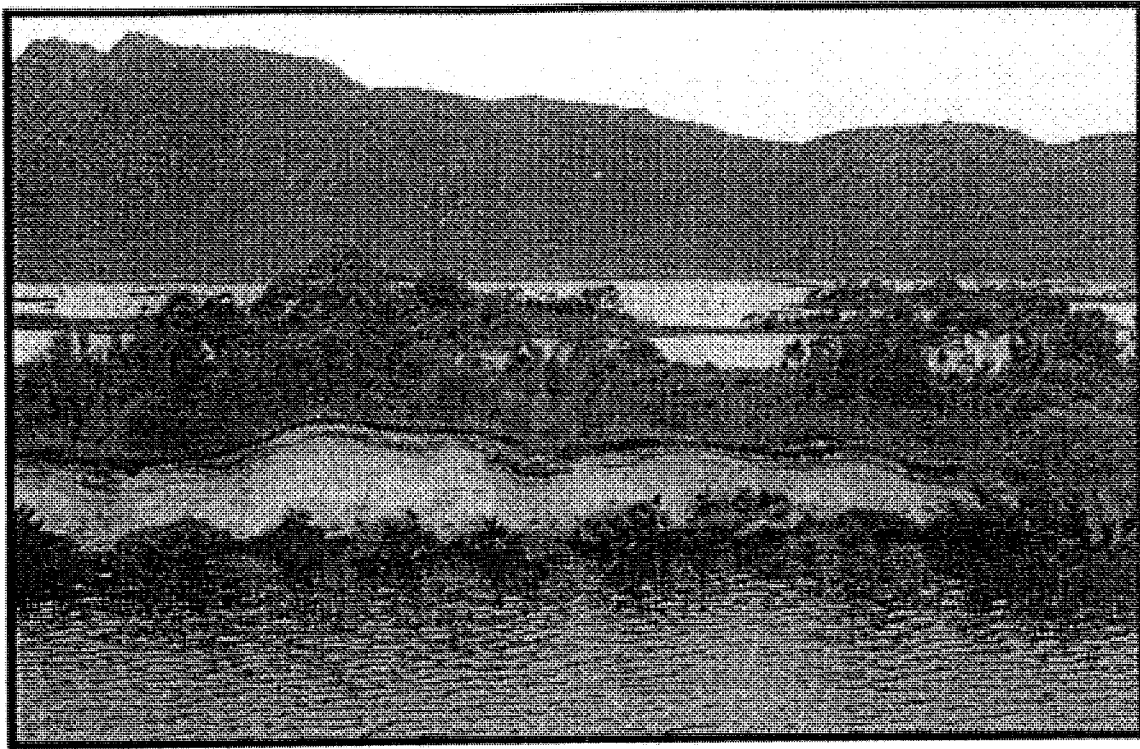
Although modification of parts of the lunette system is to be anticipated, the extent of erosion during the filling stage when it was most subject to attack by erosive waves was not great. Evidence for this is available from personal observations by the writer, who visited the site during the filling process, and from photographs taken as the dune was progressively over-run by the rising waters in the dams. The worst eroded area appears to have lain north of Maria Creek and extended for ~300 - 500m along the dune face. In this area virtually no part of the dune face was unaffected. Removal of sand by waves led to collapse onto the beach of vegetation from the margin of the frontal dune. For the most part, however, smaller shrubs greatly predominated over taller trees. The dune face failures in this area appear to represent up to ~3m of face recession. However, since the minimum width of the dune in this area is ~60m, recession of 3m represents barely 5% of its width. Erosional trimming of the very much broader dunes south of Maria Creek also occurred, but because these are lower than those to the north, they were close to being insulated below the depth of effective wave erosion at the time the waves were most effectively eroding the higher dune to the north. No evidence of tree collapse indicative of dune erosion was observed on the lunettes at Maria Lakes during site inspection as the dams filled in 1973. The Maria Lakes dunes were protected by the main Pedder dunes from the strongest wave action caused by the prevailing westerly winds across the filling impoundment. No collapse is evident on an oblique air photo of the area taken late in the filling process.

The limited development of peat on the dunes, and the apparent absence of any record of palaeosols within the dune sands, implies that the lunette at the original Lake Pedder is not an ancient feature. Under natural conditions it was in a constant state of truncation on its windward western margin, principally due to erosion by lake water in the winter (Figure 4), and it appears to have been migrating eastward. Occasional trees that had naturally fallen from the dune face were present on the beach after each winter. Although proponents

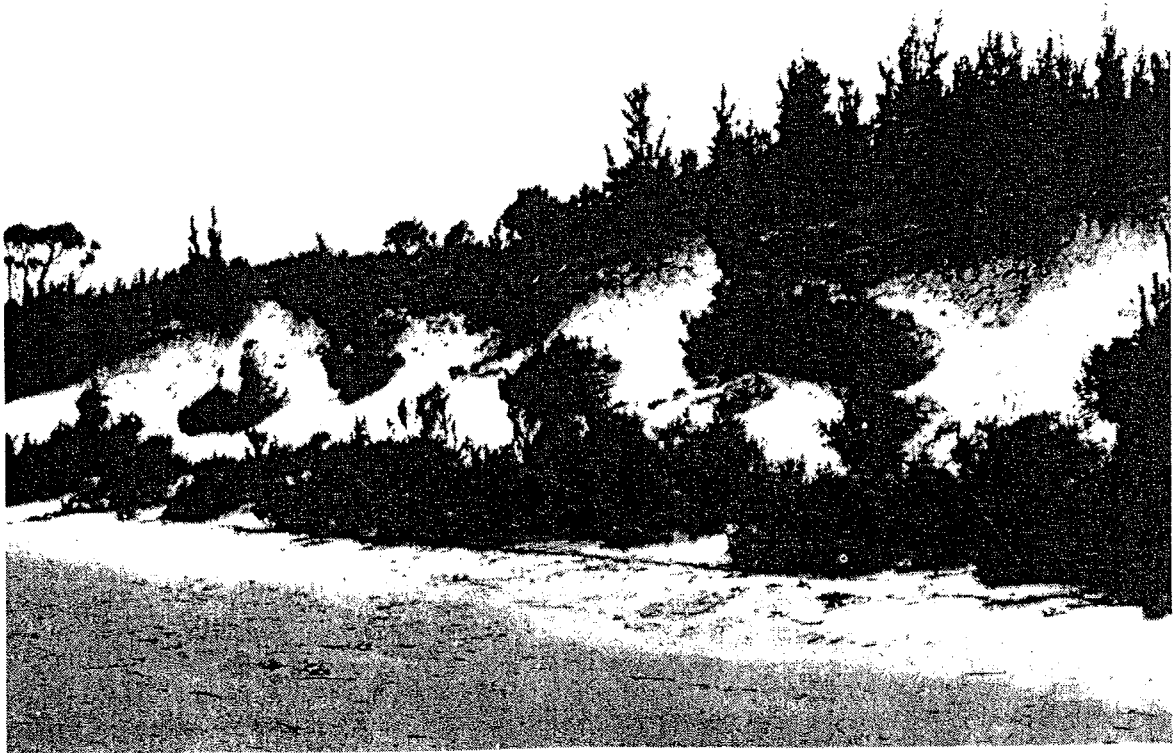


**Figure 4:** Morphology and natural evolution of the Pedder dune face. Higher water levels in winter and wave action driven by the prevailing westerly winds caused natural erosion of the dune face every winter, causing near continuous exposure of the sand face behind the beach (from Johnson 1972, p. 28).





**Figure 5a:** Photograph of the dune face taken during filling of the reservoir in July 1972 when the water level was 296.5 metres, well below the new lake's final level of 308m. This photograph was used by the pro-dam lobby in the 1970s in an attempt to promote the idea that the dunes had been destroyed, and was employed again in a misleading press campaign in 1995 (see this volume p. 7). It shows trimming but no fundamental change to the natural morphology of the dune face.



**Figure 5b:** Naturally-eroded condition of the western face of the Pedder dune prior to filling of the Huon-Serpentine Impoundment (from Johnson 1972, p. 29).

of the hydro-electric scheme made out of context claims that photographs of fallen vegetation demonstrated that the dune had been destroyed early during the filling of the dams, pre-flooding photographs of the lake consistently show evidence of windward-slope erosion and the collapse of vegetation from the dune onto the beach (e.g., Johnson 1972, p. 29, Southwell 1983, plate 48; see Figure 5). A painting by Piguénit dated c.1874 shows the lake at high winter level, some vegetation leaning outward from the dune face as if in the process of failure, and some tall leaning trees rooted into sand on the dune face from which the soil and peat cover that caps the dune had been stripped. The much photographed "Pedder Tree" on the beach by Maria Creek stood well forward of the dune face in 1973, rooted in the beach sands in a position where it would not naturally have germinated, and attesting to several metres of natural dune face recession since it germinated.

The period of erosion risk to the dunes ended early in the process of dam-filling. As previously observed, the effective depth of wave action in the Huon - Serpentine Impoundment is less than 3 - 4m even under the most extreme storm conditions. Given that the level of the impoundment is limited by statute to 1.5m of fluctuation, the Pedder dunes remain permanently well below the zone of potential wave attack.

According to informal reports from bushwalkers, the dune vegetation was devastated by fire, possibly localised, during the 1950s or 1960s. This fire and its date have not been confirmed. However, by the early 1970s there was no evidence of any increased incidence of failure of the steep westward face, and the appearance of the area was such that it was regarded by many as an undisturbed wilderness. This recovery was despite the possible loss of at least part of the peat cover on the dune due to the fire. This situation contrasts with the inundation of the area by the Huon-Serpentine Impoundment, beneath which the peat appears to remain intact. The intact condition of the peat augurs well for the likely stability and recovery of the dune after the impoundment is drained.

To summarise and put this in context, the erosion during the filling stage represented merely a temporary and very brief acceleration of a long term natural process. The dune recession that occurred in the most severely eroded area represented barely 5% of the total dune width in the locality where the dunes are most narrow, and a very much lesser proportion where the dunes are more broad. Much more severe erosion commonly occurs on some exposed ocean beach dunes during winter storms. The erosion at Lake Pedder is a much less serious risk to the critical landforms than the erosion caused by boat wakes to the banks of

the Lower Gordon River. In this latter area erosional loss from some levee banks represented more than 20% of their total breadth, but the erosion was long regarded by the Tasmanian state government as being too minor to warrant restricting vessel traffic.

#### *Severity and nature of erosion along the impoundment perimeter*

The landforms produced by glacial erosion of the Frankland Range all lie above the level of the new impoundment, as do most of the moraines that extend downslope from the cirques and short glacial troughs. These features obviously will not have been impacted by filling of the dams. However, some of the lowermost moraines extend beneath the surface of the impoundment. The impoundment waters also cover the toe of the outwash aprons that extend from the lower slopes of the Frankland Range to the valley floor and which, west of Lake Pedder, extend virtually to the foot of the Coronets. The likely present condition of these landforms following filling of the dams and two and a half decades during which wave erosion has been focussed within a narrow zone on the impoundment perimeter warrants consideration.

A preliminary investigation of the severity and nature of erosion along different parts of the impoundment perimeter by the writer allows some assessment of erosion severity in the immediate vicinity of Lake Pedder area. This erosion represents a significant land management issue for the Parks and Wildlife Service irrespective of whether the dams are drained. The methodology adopted for this survey was threefold:

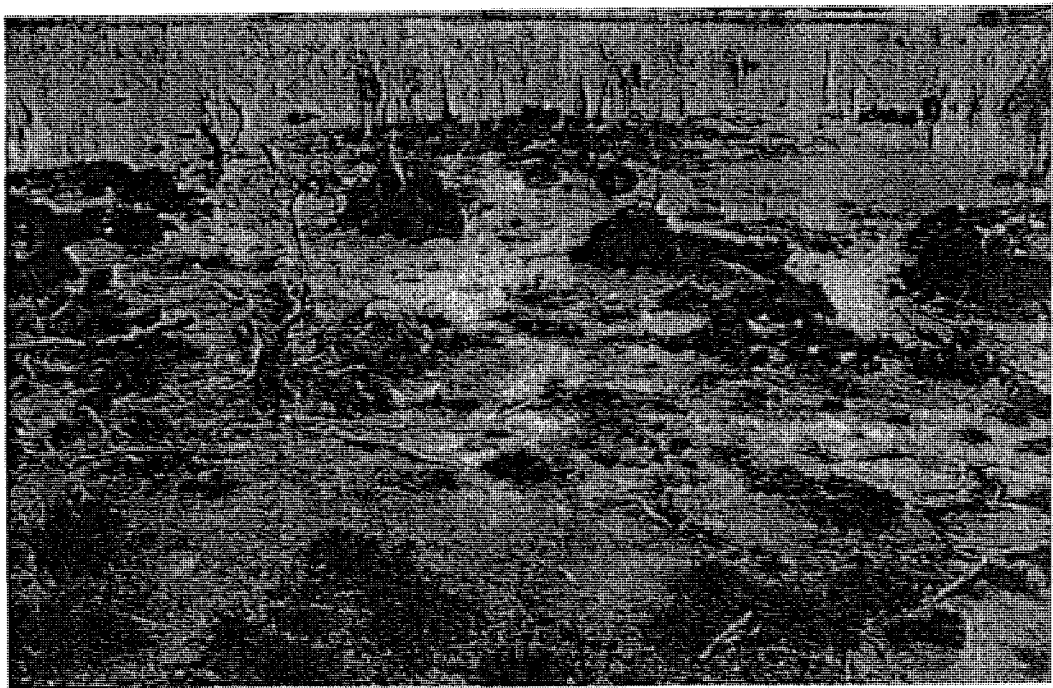
- (1) Colour vertical airphotos of the entire perimeter of the Huon-Serpentine Impoundment at ~1:25,000 scale, taken in 1988, were examined for evidence of erosion;
- (2) An arbitrary scale of visible erosion was devised and all parts of the impoundment perimeter were scored;
- (3) Ground inspections were carried out along representative parts of the perimeter in order to cross check the airphoto interpretations;

#### *Ground truthing involved:*

- Inspection of a short stretch of the perimeter from the water by sea kayak;
- Ground inspections along representative parts of the perimeter in order to determine the nature and extent of the erosion relative to slope and exposure, and the response of different shoreline materials; and



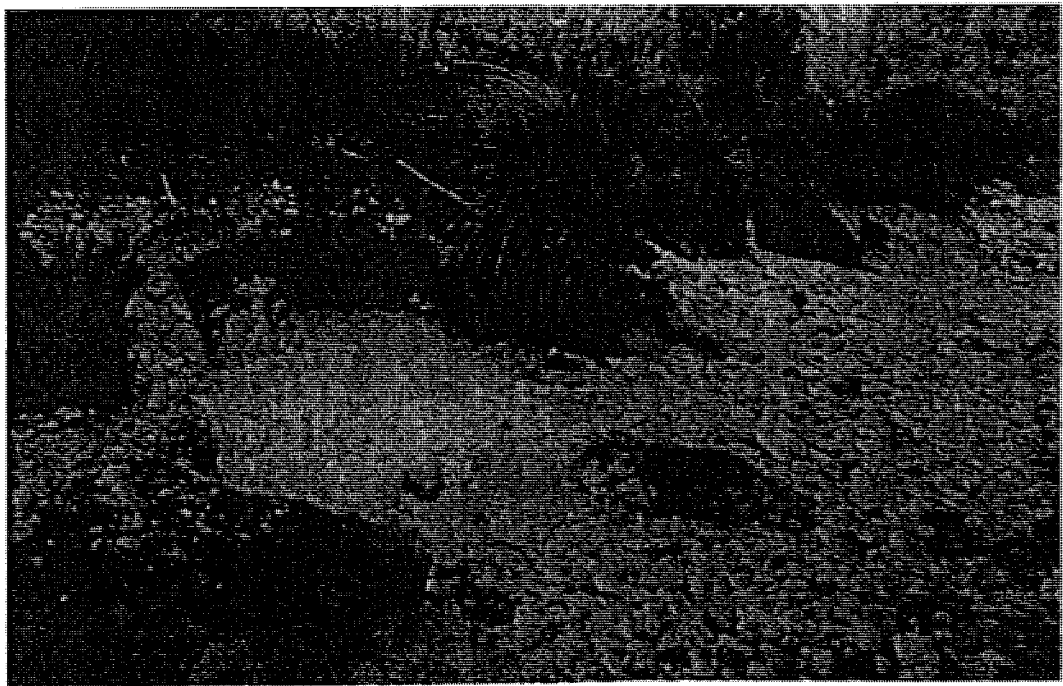
**Figure 6:** Degree 2 damage to reservoir perimeter. Inundation has killed the vegetation but wave action on the shallow lake margin has been insufficient to fragment the root mat and peat more than two decades after the reservoir was filled (photo: K. Kiernan, 1999).



**Figure 7a:** Degree 3 damage. Minor peat erosion in an embayment on the reservoir perimeter. The limited erosion and frequent exposure here allows some of the remaining vegetation to remain alive (photo: K. Kiernan, 1999).

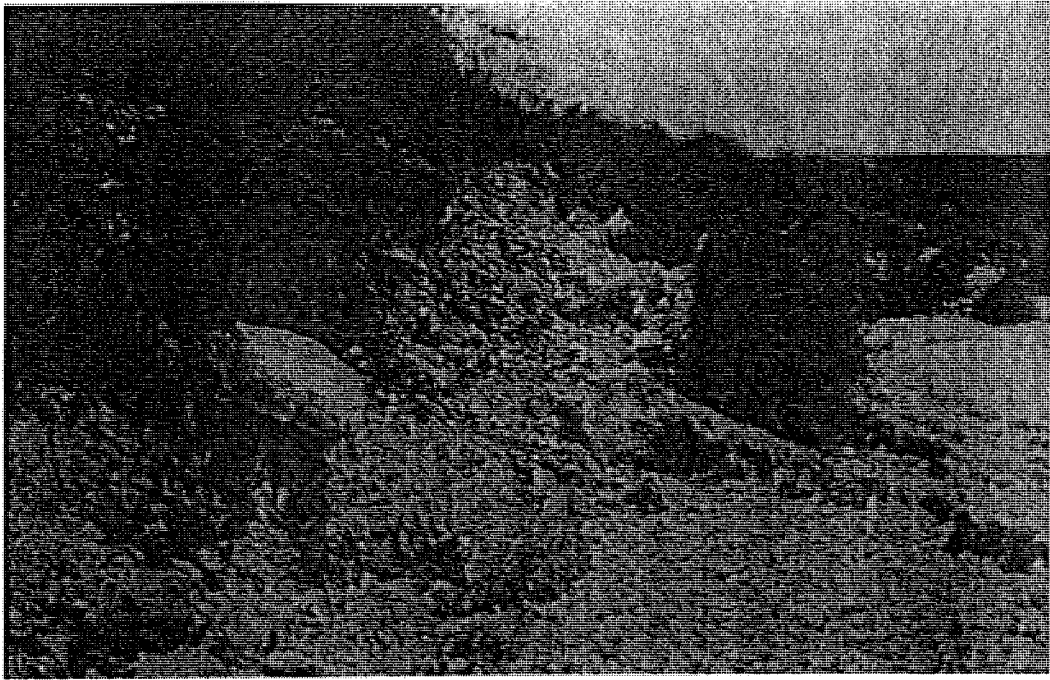


**Figure 7b:** Degree 3 damage. The pattern of peat erosion here involves the development of shallow channels up which gravels are swept and deposited on the peat further inshore. In more severely affected areas confluence of the erosion channels proceeds to the formation of remnant peat islands (photo: K. Kiernan, 1999).

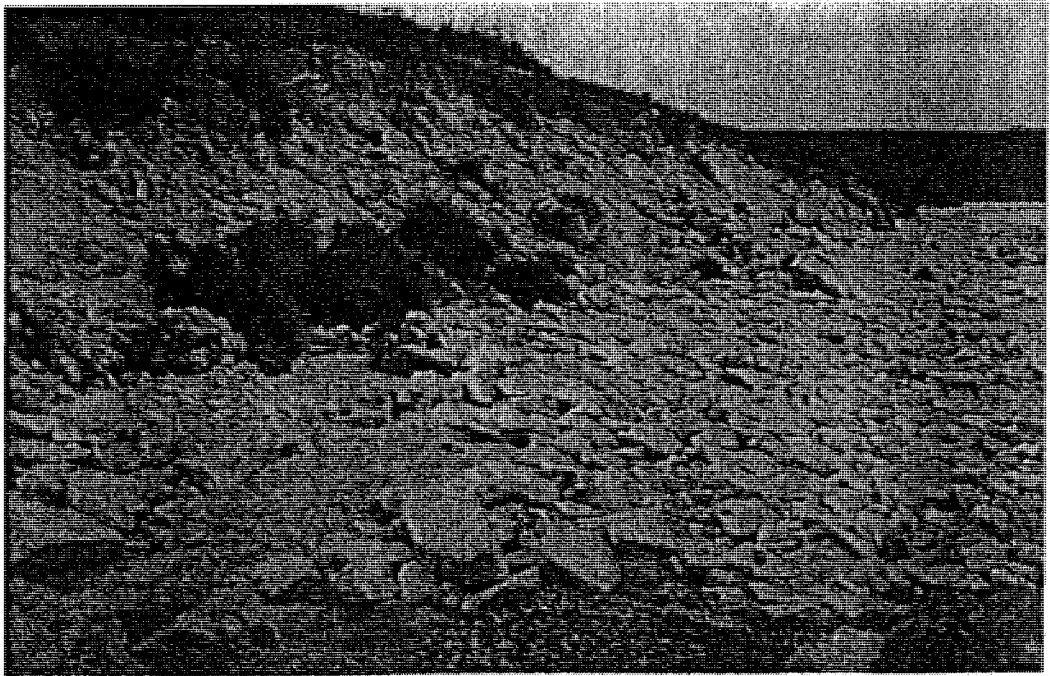


**Figure 7c:** Degree 3 damage. Cliffling of sandy regolith in embayments between remnant peat promontories (foreground). Minor tunnelling in loose regolith beneath peat at head of embayments (photo: K. Kiernan).





**Figure 8a:** Degree 4 damage. Scarp about 1m high eroded in surficial sediments overlying bedrock on a steep, exposed shore. Loose material from the regolith has been drawn down onto the lake margin by backwash. Deeper erosion is inhibited by the shallow bedrock (photo: K. Kiernan).



**Figure 8b:** Degree 4 damage. Scarp 2 - 3m high formed entirely in surficial sediments east of Scotts Peak Dam. This major cliffing is at the most severely eroded site identified during this survey, and is located at the exposed southern end of the reservoir. The blocks and cobbles in the foreground have been reworked from the regolith with the larger rocks piled towards the back of the beach by wave action (photo: K. Kiernan).



**Figure 8c:** Degree 4 damage. Stripping of shallow peat to expose a bedrock shore on a steep margin of the reservoir west of the Scotts Peak Dam exposed to the full fetch of the largest waves (photo: K. Kiernan).

- Examination of the bed of the lake to depths of up to 2m below the water surface along parts of the impoundment perimeter, that is, exceeding the span of water level fluctuations permitted by statute.

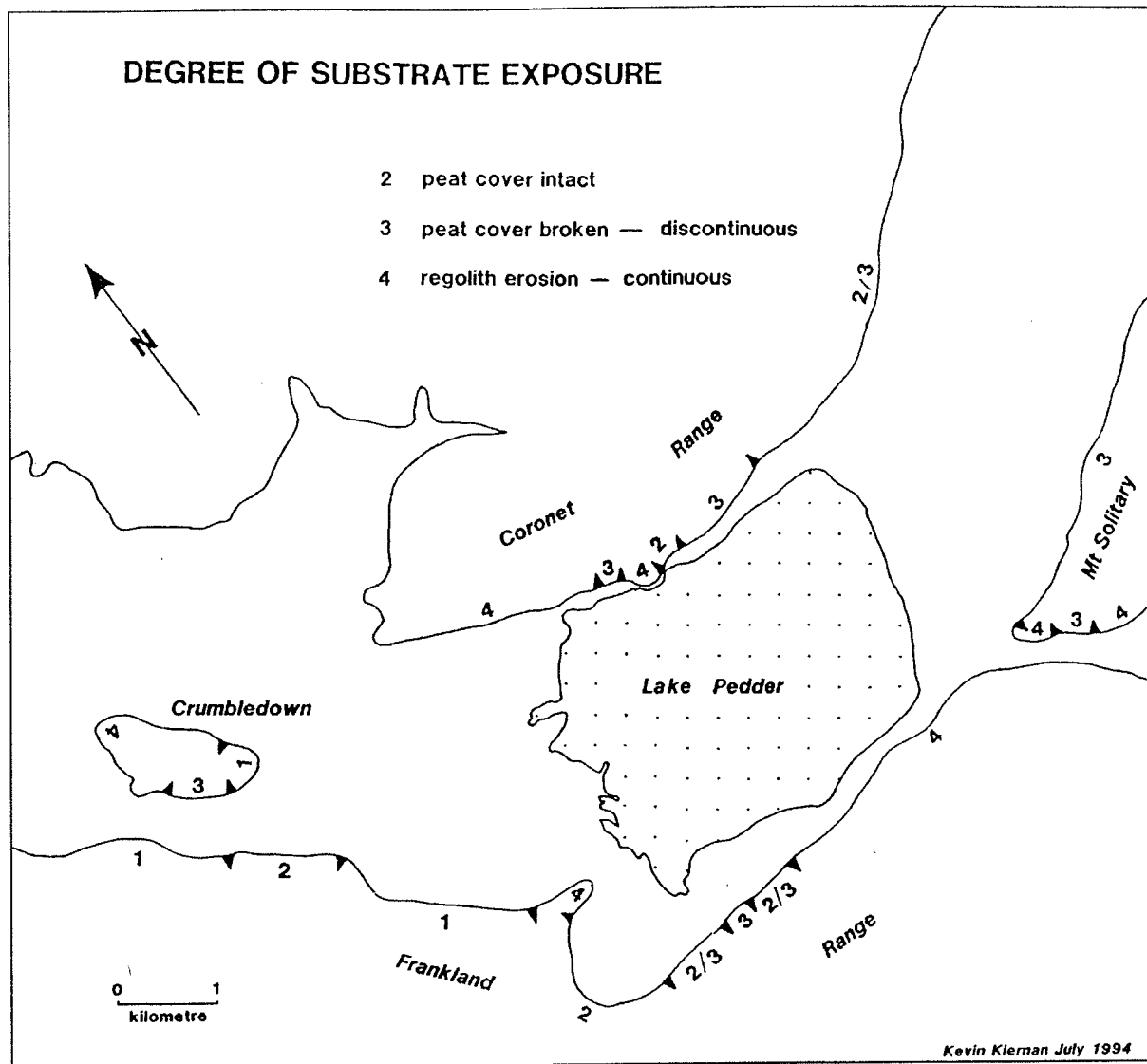
The scoring system adopted was: (1) only partial death of vegetation at the impoundment margin and no exposure of regolith; (2) vegetation death but no evidence of regolith exposure (Figure 6); (3) discontinuous visible damage (Figure 7a, b, c); (4) continuous visible erosion (Figure 8a, b, c); and (5) severe damage due to dam construction activities. It should be recognised that the use of vertical air photos means that the visibility of erosion is reduced where the erosion scarp is steepest and potentially highest. To some extent this problem is compensated for by the fact that the photos are in colour and the white quartzite scars show up very clearly on them. However, one of the aims of the ground-based and water-based inspections was to obtain some impression of the extent to which erosion may be under-represented as a result of deficiencies in the air photo perspective. Although only a limited number of sites were ground-truthed, in no case has the erosion proved to be more severe than what was suspected from the air photo interpretation. This is probably partly due to the limited amount of very steep ground, the impoundment being shallow over the valley floors and its surface impinging for the most part on relatively gentle footslopes.

Unfortunately, during compilation of this paper the lack of suitable craft meant that it was not possible

to revisit on the ground those parts of the impoundment perimeter on the Frankland Range in closest proximity to Lake Pedder. However, observations have been made on the nature and extent of the erosion in a number of other localities. These have included:

- the foot of the Coronets immediately north of Pedder Beach, reached after following the route of the old Lake Pedder track over the Sentinel Range;
- the exposed eastern margin of the impoundment south of the old Huon Crossing campsite and north of Harlequin Hill;
- the exposed southern perimeter in the Lake Edgar area, including the area of the Lake Edgar fault scarp; and
- the exposed southern perimeter between Scotts Peak Dam and McKays Point.

Greatest emphasis during the ground inspections was deliberately given to those parts of the impoundment perimeter most exposed to wave attack, that is, along its downwind eastern and southern margins, in an effort to determine a worst case scenario. While by no means exhaustive or definitive, a useful first approximation of erosion types around the storage perimeter has been obtained (Figure 9). This facilitates some interpretation of the extent of erosional modification of the natural landforms along the impoundment perimeter in closest proximity to



**Figure 9:** Reconnaissance map of erosion severity around the perimeter of the Huon-Serpentine Impoundment in the vicinity of Lake Pedder.

#### Lake Pedder.

Ground inspection revealed that the most serious erosion damage comprises the stripping of regolith from bedrock slopes, exposing a rock scarp. Such damage is focussed primarily on steep slopes, especially on ridges that project into the impoundment. Where steep linear slopes or embayments have been exposed to the full fetch of the waves west of Scotts Peak Dam, the regolith has been quarried very effectively, exposing bedrock faces up to 3m high (Figure 8c). Material has been quarried out from joints previously widened by weathering to produce small caves that sometimes extend 2-3m. The regolith removed in these areas consists primarily of slope deposits. Only very rarely is there evidence for the removal of toe support from these slope deposits having

caused landslides that have migrated upslope (Figure 10). This is due to the generally low angles and lengths of the slopes and to the nature of the component clasts and matrix of the surficial sediments. Since these have been stripped to well above the surface of the impoundment there is no evidence to suggest that the water itself provides any sort of buoyant support to the material that would be lost when the dams are drained, threatening slope failure.

While some sheet wash effects are to be anticipated, where ridges projecting into the impoundment are of very gentle gradient, as at the present McKays Point, the regolith has not been exposed; the peat mat remains intact with plant remains still in growth position even in the zone of maximum wave activity at the impoundment

surface. The same situation applies where linear slopes or embayments are present but the gradient is low. Some of these areas are probably underlain by alluvial sediments but this cannot be confirmed since the peat cover remains intact.

The exposed peat has sometimes become patterned by desiccation cracks (Figure 11a), which are likely receptacles for seed and nutrient capture and hence foci for revegetation when the reservoir is drained. A similar pattern of regrowth from peat desiccation cracks has been observed on the floor of Lake King William and some other artificial reservoirs when their floors have been exposed during protracted periods of lake drawdown.

From the air photographs some sites appear eroded but the conspicuous white material only thinly mantles peat that remains intact with the potential to provide a growth medium for plants when the reservoir is drained. These uneroded sites cannot be differentiated from areas of erosion into the substrate without detailed ground inspection. Hence, it is likely that some proportion of those areas of the reservoir perimeter scored from the airphotos as having been damaged to degree 3 or 4 will in reality be damaged no more than degree 2 (Figure 11a, b, c).

*Extent of erosion damage on Pedder-facing slopes*

From the perspective of geoconservation, the critical slopes that may potentially have been damaged are those of the landforms genetically related to Lake Pedder. Since the most severely scarred areas potentially represent the sites of greatest damage to the geomorphology, some assessment of the aesthetic impact dovetails usefully with approximating the impact of wave erosion on the geoconservation values. However, it needs to be stressed that the following paragraphs relate to short-middle term aesthetic concerns only, albeit these are concerns that opponents of restoring Lake Pedder may seek to exploit.

Within the immediate environs of Lake Pedder, erosion evident on the air photos and scored at degree 2/3 predominates east of where the Sentinels track reaches the lake shore. This has been confirmed in broad terms by ground inspection, although for the most part while the regolith has been exposed incision into it has generally been limited except on the steepest slopes. Further to the west towards Buckies Bonnet erosion of degree 3/4 is evident. On the Franklands side of the impoundment, regolith scarring severity is degree 4 along the northern margin of Terminal Peak, where waves generated further to the west in the Serpentine Valley impact upon the slopes after a long northwesterly fetch. Erosion of this severity is also evident at the present Cripps Point and at Crumbledown. The lower slopes of Frankland Peak and Greycap, and the remainder of the

Franklands perimeter as far as Crumbledown, is damaged to degree 2 or 2/3. By definition, the latter category comprises only limited lengths of shore with continuously evident scarring, there being within this category extensive areas of only degree 2, particularly northwestwards of the present Cripps Point.

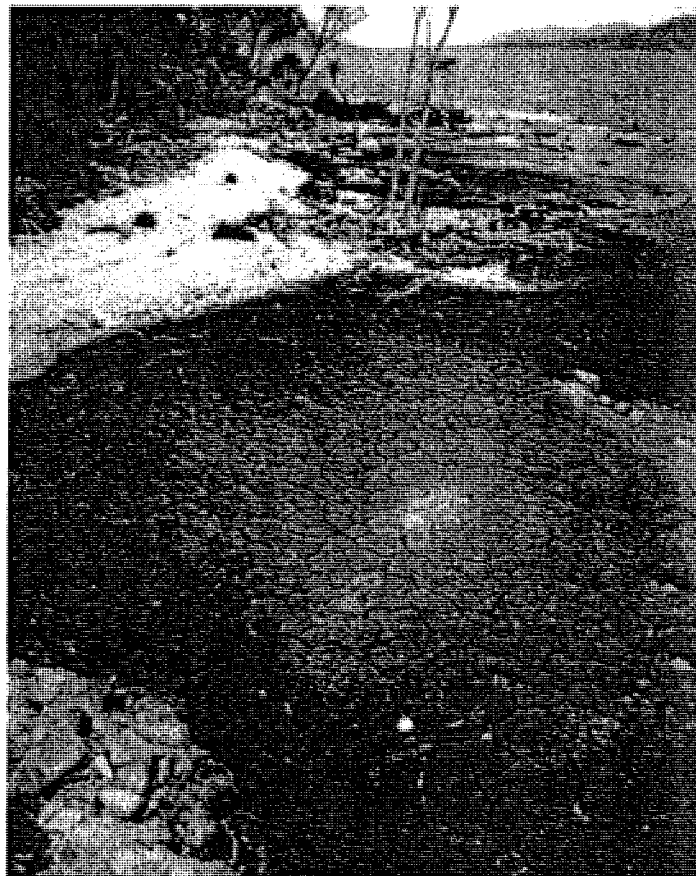
Degrees 1 and 2 essentially imply no significant damage since the regolith has not been exposed. On this basis, most of the perimeter shoreline visible from Pedder Beach will reveal no scarring at initial exposure. To judge from areas flooded during initial filling of the Gordon Impoundment but exposed for over a decade since, and where the peat mat similarly remained intact, these margins of the Franklands and Coronets can be expected to revegetate naturally fairly quickly. Since degree 3 implies discontinuous damage with intervening unscarred areas, ~50% of these perimeters should also revegetate fairly quickly, while the visual impact of the scarring is moderated by the discontinuities. On the northern margin of Mt Solitary damage is again predominantly degree 3 with some areas of 4, not visible from Pedder Beach other than possibly at Maria Creek, but evident from elevated viewpoints on the Coronets, as would be the scarring on the Franklands. From the Frankland Range the less severe scarring along the Coronets will initially be visible. Scarring of the Coronets will also be evident from Mt Solitary, although from that point only limited scarring will be evident further east in the Maria Creek catchment due to the very limited damage occasioned to the low gradient valley floor in that area. The scarring along the northern flank of Terminal Peak will also be largely hidden from Mt Solitary, although that along the eastern flank of Terminal Peak will be evident from some positions on the mountain.

The most serious damage caused by wave erosion are the degree 4 areas at Terminal Peak, the present Cripps Point and at Crumbledown. Degree 4 scarring represents only ~20% of the impoundment margins visible from Pedder Beach, or at most 30% taking into account the most serious sites within degree 3. Given the limited vertical amplitude of the wave eroded zone, and remembering that the air photo interpretation does not accurately represent the gradient on the ground, a better impression can be gained by relating the air photo observations to the gradient evident from maps and from photographs taken from the valley floor and beach. This latter exercise suggests that, from an aesthetic perspective only, when the dams are first drained serious scarring will be visible from Pedder Beach in only a limited number of areas and often at a considerable distance. The highest visual impact is likely to be the scarring on Terminal Peak. The other significantly scarred areas in the viewfield from the beach will be 4 km distant in the case of

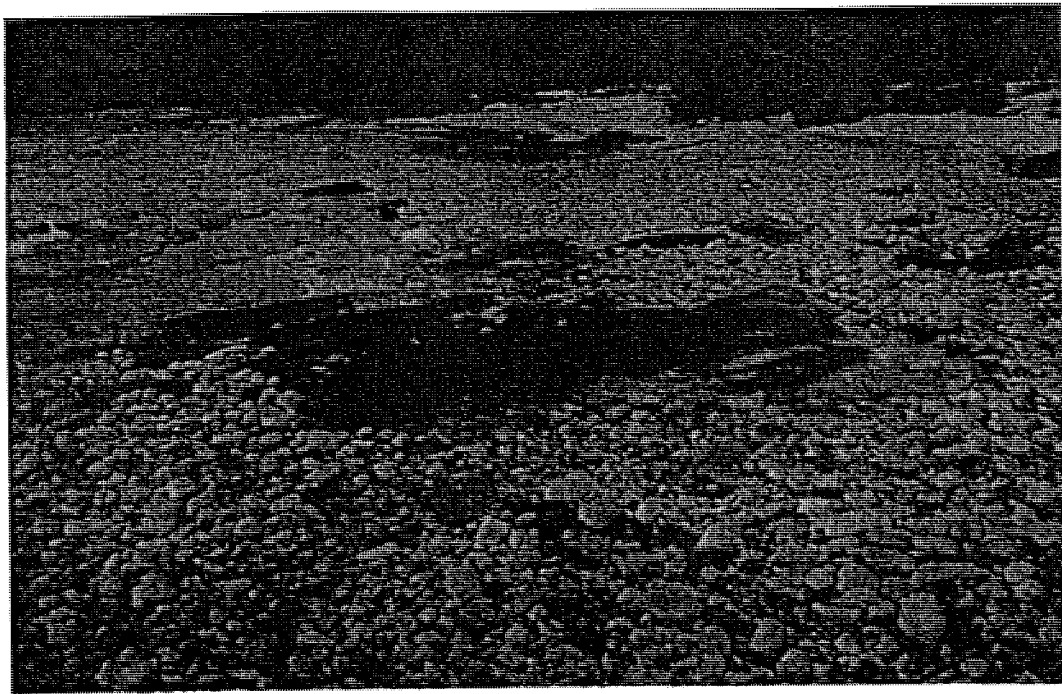




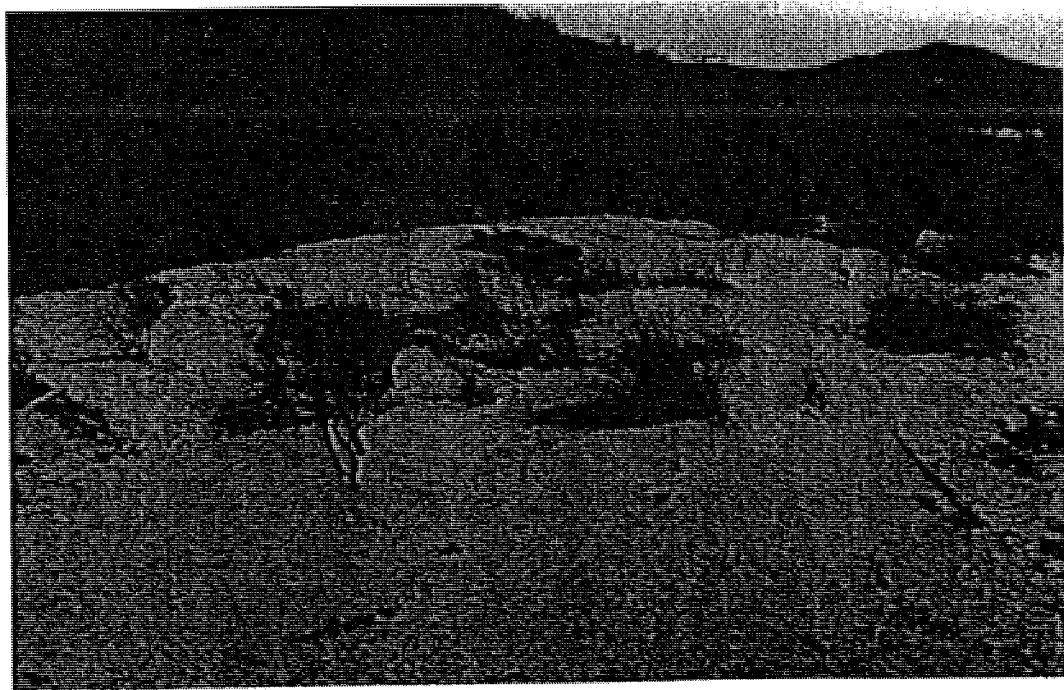
**Figure 10:** Small landslide on reservoir perimeter west of Scotts Peak Dam, caused by wave erosion removing toe support from slope deposits. Slope failures of this kind appear uncommon around this reservoir (photo: K. Kiernan).



**Figure 11a:** Peat soil survival despite an appearance of erosion. Intact peat on the southern perimeter of the impoundment. Despite apparent exposure to the full fetch down the lake the shallow shore reduces wave action. The intact peat exhibits desiccation cracks that can form receptacles for seeds and nutrients. The white material inshore of the peat is not regolith exposed by peat erosion, but merely a thin veneer of gravel deposited on the peat by wave action. The presence of gravels implies they have been eroded from elsewhere. Since there is no erosion of the peat on the shore it is likely that longshore drift has been involved, but erosion from deeper water forward of the peat cannot be discounted entirely (photo: K. Kiernan).



**Figure 11b:** Intact peat thinly overlain by gravels and cobbles deposited by waves along the exposed southern margin of the impoundment. Again, the peat remains available as a potential growth medium for plants when the impoundment is drained (photo: K. Kiernan).



**Figure 11c:** Formation of small beach ridges has here involved the dumping of gravels on living vegetation by wave action. Again the eroded appearance is deceptive, and a viable medium for plant growth remains intact beneath the sediment. Similar small storm-beach ridges encroaching onto living vegetation could be found along parts of the southern shoreline of the original Lake Pedder. The coarse calibre of the lakeshore sediment in this and earlier photographs is typical, and in contrast to pre-dam promises that sandy beaches equivalent to that at the eastern end of the original lake would rapidly form to replace it. This was never a serious proposition because the source of the Pedder beach was fine wind-deposited sand naturally eroded from the face of the Pedder dune each winter and spread onto the floor of the original lake basin. No similar large source of windblown sand is available around the margin of the artificial Huon-Serpentine Impoundment (photo: K. Kiernan).

the present Cripps Point, and 12km distant in the case of Crumbledown. However, the vertical range of the erosion scarp or area of exposed regolith is likely to be no more than 3 - 4 m at most, hence only limited vegetation re-establishment at the foot of the scarps will be necessary for the scarp faces to be hidden from view. Where the exposed regolith involves material washed into the perimeter of the impoundment from eroded areas on its margin, the slope of the lower part of the scar is generally considerably less than the scarps. This will mean easier re-establishment of vegetation, which will be aided where the peat mat remains intact beneath the debris. Given time, much of this perimeter scarring will become inevident, and may be interpreted by visitors as simply a natural line of outcrops in those areas where they remain visible, not dissimilar to the natural fossil shorelines that are often evident around the margins of lakes.

However, these observations relate largely to visible aesthetic impacts, rather than to geoconservation values. The potential exists for the latter to have been compromised to at least some degree if the erosion has modified the natural morphology of the pre-flooding landforms. The paragraphs that follow assess this latter possibility.

#### *Moraines*

Moraine ridges that extend from the Franklands to below the level of the impoundment surface occur in the area between Greycap and Frankland Peak, possibly at the drowned extremity of the present Cripps Point, and below several of the valleys towards Crumbledown. None of the confirmed moraines bear evidence of scarring of greater severity than degree 3, most being degree 2. All the confirmed moraines present relatively low slope angles to the waves, minimising erosion. Hence, the surface contours of the moraines appear unmodified, possibly entirely so, and their geoconservation values remain intact. The possibility exists that a recurved ridge that extends from the nose of the present Cripps Point is a moraine, but it has not proven possible to confirm this during the course of this survey. Scarring of the present Cripps Point is to degree 4 but it may relate to the scarring of a bedrock ridge (Calver *et al.* 1990) rather than a moraine, any moraine extending beyond the rock ridge and presently being entirely below water level. If this is the case, then any moraine here may not have been modified either.

#### *Outwash aprons*

The coalescing outwash fans that extend downslope from the glaciated sites on the Frankland Range occur along much of the perimeter of the Huon - Serpentine Impoundment in the Lake Pedder area. Once again, the slope gradient is generally low at the point where the impoundment surface impinges

upon it. The vast majority of the outwash aprons have not been scarred to more than degree 3, the vast majority being scored as only degree 2. The exception is the zone of degree 4 scarring along the northern margin of Terminal Peak, which, to judge from the severe scarring around Scotts Peak Dam, may have been incised by up to 4 or 5 m. This is a relatively modest impact given the overall size of the outwash aprons, which are up to 1 km broad and retain their essential form despite this slight notching. The aprons are also likely to have retained their natural morphology below water level and certainly have done so above the level of the impoundment. It was the relative absence of glaciofluvial and alluvial fans in the Terminal Peak area compared to their much greater extent further west that led to the original formation of the Lake Pedder basin (Kiernan 2001). Some minor additional sculpting of the fans below Terminal Peak is of limited consequence to the integrity of the Pedder landform community.

#### *Fluvial landforms*

The most significant fluvial landforms in the Pedder area all now lie well below the level of the impoundment surface. These features include the meandering channels of the Serpentine River and the lower reaches of tributary creeks that discharge from the Frankland Range, and the braided channel of Maria Creek. Tyler *et al.* (1993, 1996) have demonstrated that the channel of the Serpentine River and one targeted tributary stream both remain intact near the margin of Lake Pedder. This is consistent with the situation known to exist beneath some other hydro-electric impoundments elsewhere in Tasmania. For example, very low water levels in Lake King William during recent years have permitted access to the original channels of the Derwent River and other streams in that locality (Kiernan 1985), with there being no evidence in that case of any change in the plan forms of the channel systems since the Clark Dam was filled.

#### *Other features of geoscientific interest*

The broad topographic framework of the Lake Pedder area is the product of preglacial weathering and erosion acting upon different rock types and geological structures. Establishment of the Huon - Serpentine Impoundment has not had any impact on this broad topographic framework or geology. At a smaller scale, a significant portion of the Lake Edgar Fault scarp has been inundated by the impoundment. There is little evidence of any major damage to this apart from that caused by construction activities immediately adjacent to the Lake Edgar dam. The fault scarp faces east hence it does not form an exposed impoundment perimeter. Given the very limited potential for sediment accumulation as already outlined, there is virtually no likelihood of the fault scarp, which is up to ~5m high, having been buried by sediment. It

can reasonably be anticipated that Lake Edgar and its companion sag pond remain intact.

#### SOME CONSIDERATIONS REGARDING THE DAM-DRAINING PHASE

For about two and a half decades the level at which the lake water surface impinges upon the surrounding slopes has been ~15m higher than was naturally the case. This has minimised wave erosion of the main shoreline landforms around the natural lake. The most vulnerable lakeshore landforms are the sand dunes along the eastern margin of Lake Pedder. These were subject to accelerated wave erosion during filling of the storage, and this situation will be repeated as the artificial reservoir is drained. There may be two factors to be considered here in devising the optimum draining regime. The most obvious period of risk for the dunes is that during which the lake surface impinges on the dunes. However, prior to that some risks may be posed as the water surface drops to the point at which wave action exerts leverage on the dead trees that remain in growth position rooted in the sand. Under normal conditions trees dead for 20 years may be weakened by decay and break off easily, but Tyler has recovered undecomposed sedges which suggests that larger trees may not have lost much strength - the strength of wood buried in Quaternary deposits in various parts of the state, including wood hundreds of thousands of years old that is buried beneath the Linda moraines (Kiernan 1983), emphasises the potential for considerable strength to remain in some circumstances. Acid conditions at the floor of the present artificial reservoir are likely to impede decomposition (Tyler *et al.* 1993, 1996). The down-side of standing trees still being present is the possibility of their being levered by the waves and thus tearing the protective peat and root mat, the up-side is that competent roots may continue to bind the soil together and protect the underlying sand, which would be an asset during the recovery phase.

Drawdown therefore needs to occur as rapidly as possible when, and shortly before, the dune face is exposed. If possible, it should be timed for when conditions are least likely to be stormy so that wave action is at its least, and for when the receiving rivers are naturally at low stage so that downstream damage is avoided. Erosion around the perimeter of the Huon - Serpentine Impoundment as the water level drops is likely to be minimal provided drawdown is achieved reasonably rapidly.

Landslides on the margins of artificial water storages in response to drawdown are well documented phenomena, but in the case of the Huon - Serpentine Impoundment appear relatively improbable for several reasons. First, for the most

part the surrounding slopes are not steep. Second, the peat mat below the present level of wave action appears to be intact, which will help hold the regolith in place. Third, the bedrock geology of the slopes is predominantly quartzitic and the regolith to which it gives rise is low in clay and relatively high in sand, hence there is little problem with failure-prone clay-rich slope materials.

Consideration must also be given to the impacts on the receiving river channels when the Huon - Serpentine Impoundment is drained. The situation with respect to the Huon River is somewhat different to that with respect to the Gordon River. In the case of the upper Huon River, its discharge has been very much reduced since the dams were filled. It can be anticipated that because of the build-up of sediment within the river channel its capacity is now significantly less than it was, due to reduced stream competence, at least in its upper reaches. Hence, care will have to be taken to determine appropriate discharge levels in order to minimise any risk of bank erosion and overbank flow by the initial dam draining. Prior study of the channel will be required. After a cautious start, it should be possible to increase the rate of discharge as the re-invigorated flow scours the channel back closer to its previous form.

The channel of the Serpentine River downstream of the dam is also likely to have a lesser capacity than previously. The length of channel above the confluence of the Serpentine with the Gordon is relatively short, and its steep gradient should allow ready scouring. That it is a gorge that was previously subject to significant floods means that the likelihood of potentially damaging overbank flow, such as could perhaps occur in the upper Huon, should be much less in the lower Serpentine Valley.

In contrast to the river channels downstream of the Huon and Serpentine dams, significant discharge has been maintained downstream of the Gordon Dam. Due to the outflow from the power station, river levels are now more even than was naturally the case. Flood peaks are now moderated but higher than natural river levels are maintained during the drier months of the year. In addition to the biological impacts that may have resulted downstream from this change in river levels and water temperature, and in addition to the impacts caused to the meromictic lakes beside the Lower Gordon, these alterations to river levels may also have contributed to riverbank erosion problems. In particular, boatwakes with the potential to erode the river banks are now focussed higher on the bank profile than was the case prior to filling of the dams, and boatwake impact is now confined to a narrower vertical range. When the Huon - Serpentine Impoundment is drained particular care will need to be taken to ensure that these negative

downstream impacts of the power station are not compounded. If the Huon - Serpentine Impoundment cannot be pumped into Lake Gordon and discharged through the power station, then discharge from the power station itself should perhaps be reduced or halted while the impoundment is drained.

## CONCLUSIONS

Tyler *et al.* (1993, 1996, summarised in Tyler 2001) have demonstrated that the Lake Pedder landform complex remains intact beneath the Huon - Serpentine Impoundment. Although their consultancy was brief and their investigation could not be exhaustive, their results are entirely consistent with what could be predicted on the basis of first principles, the landforms types involved, the materials present, the processes in action, observations made as the dams filled, and evidence gathered from around the impoundment margins since that time.

The critical landforms of the Lake Pedder geomorphological community were subject to accelerated erosion processes as the dams filled but only for a very short time and with minimal impact. Since that time they have lain well below the level of effective wave erosion. The likelihood of significant volumes of sediment having accumulated in the Pedder basin, on the beach or on the bar is negligible. At any rate, the minerogenic sediment that has entered the impoundment has been fluvially derived from upslope or quarried by waves from the shoreline, from the same bedrock and surficial sources as produced the lake bed sand mass. The regime of the streams is not conducive to transport of the coarsest fractions (cobbles upwards). The streams discharge into the impoundment which impedes their capacity to transport sediment, hence all but the finest sediment would have been stranded well short of the original lake basin anyway. Any finer minerogenic material would simply have supplemented the huge amount of entirely similar material already forming the original lake bed, beaches and dunes. Nor is there any reason to anticipate much organic sediment accumulation. There is little source for fine organic sediment other than that of planktonic origin. The surficial stratigraphy comprised fibrous peats over muck peats formed directly on siliceous regolith, with little pedogenic alteration of the regolith. That the fibrous peats remain intact just below the zone of maximum wave erosion, and form a mat that traps the muck peats, is evident along parts of the impoundment perimeter that have been examined. The attempts by Tyler *et al.* (1993, 1996) to sample organic sediment from beneath the reservoir at the site of Pedder Beach largely failed due to the virtual absence of any sediment in all the areas they

examined. This led the authors of that report to conclude there was virtually no sedimentation - an entirely predictable result. A single winter's storms would remove the tiny amount of organic sediment likely to be present once the impoundment is drained.

On theoretical grounds the bar, mega-ripples and beach should have remained intact, and evidence for this being the case has been provided by Tyler *et al.* (1993, 1996). At any rate, these features are the product of postglacial processes like those of the present day, and could have been expected to have re-established rapidly even if they had been largely destroyed. Tyler *et al.* have further demonstrated that Pedder Pennies remain abundant on the floor of Lake Pedder and the dune systems appear to remain intact. Observations made during the filling of the dams indicates only minor damage was caused by accelerated erosion of the dunes at that time, while the presence of the peat cover over the dunes will serve to retain the form of the dunes as well as serve as a growth medium for revegetation of the area. This is likely to remain the case for some time to come, but not indefinitely. It can be anticipated with reasonable confidence that Lake Pedder beach will appear much as it was within a few months of its re-exposure, if not sooner. The same natural processes of wind on sand that originally produced the dune will restore the form of its slightly eroded western face over one or two summers of exposure.

The surrounding complex of landforms that forms part of the Lake Pedder genetic community also remains largely intact. Bedrock beneath the regolith mantle has been exposed by wave action along some steeper parts of the impoundment shoreline, but where slopes are more moderate the damage has been less severe with low angle cobble beaches formed. In most shallow embayments the peat has not been stripped. Even in the areas of most concerted wave attack, the peat remains intact on the impoundment floor 1-1.5m below normal full supply level. Exposure of the eroded area to the rains once the storage is drained obviously implies some risk of fluvial erosion, but the severity of this is likely to be very much less than the erosion presently being caused by the waters of the impoundment due to wave action. Given the very limited height of the eroded scarp, and the low level of impact in that part of the impoundment immediately surrounding Lake Pedder, revegetation is likely to soon mask most of it. Indeed, from Pedder Beach little of the scar is likely to be visible over the foreshore dunes, and, later, the lakeside vegetation should mask most of the remnant scarring completely while the scars themselves recover. As further vegetation builds up behind the screening vegetation at the scarp foot, stabilisation should occur naturally in all but the worst affected areas, given time. After only two and a half

decades even the much more severely scarred bulldozed areas adjacent to the Gordon River Road have revegetated in all but the very worst affected areas.

More active human intervention may be necessary to rehabilitate parts of the perimeter of the artificial storage where wave action has been most intense, slopes are steepest, and bedrock has been exposed. The demonstrated effectiveness of modern rehabilitation techniques, as shown for instance by the Hydro-Electric Corporation's own recent efforts in rehabilitating scarred areas around its construction sites at Red Hill Quarry near Scotts Peak and on the King and Henty - Anthony schemes, means that the restoration of Lake Pedder can be complemented by rehabilitation of the eroded margins of the drained storage. Since ground disturbance by vehicles must be avoided, it would make sense to utilise barges to place needed materials in advance. It may prove possible to hold the lake level slightly below its present position for a short time without significant damage, such that some equipment might be operated from barges.

In purely aesthetic terms, even in the short term the intrusion of the impoundment shoreline scars would probably be no worse than that of the canal by-pass alternative to the Huon-Serpentine Impoundment once considered quite acceptable and actively promoted by the conservation movement. However, opponents of the restoration of Lake Pedder can be expected to focus attention on the short term aesthetic scarring in a bid to win support for their cause, despite the fact that the scars will fade with time and despite the lack of any significant impact by impoundment shoreline erosion on the geoconservation values. Any public perception that a massive area has been devastated will have to be replaced by an awareness that the actual area over which the substrate has been exposed is very much more limited than the total area of the impoundment. It is akin in extent to that produced by discontinuous stretches of four wheel drive track, but often with a lesser depth of incision.

Any human intervention in the restoration process around the lakeshore will have to be very carefully planned well in advance, with an adequate lead time allowed for this to take place. The Red Hill Quarry near Scotts Peak, until recently one of the great aesthetic tragedies of southwest Tasmania, disfigured the landscape from all the surrounding ranges. This quarry was developed to supply argillite rock fill for the dam, rather than use natural gravel from less visibly intrusive sites on the valley floor. However, engineering geologists associated with construction of the scheme have recorded (Roberts *et al.* 1975) "the relative merits of natural gravel and poor quality rock were finely balanced. Had the thicker gravel deposits near the

dolomite quarry been discovered a year earlier the decision may have gone the other way, with equally satisfactory results." And with far less devastating results for the Tasmanian wilderness. Similarly rushed decision-making in relation to the methods employed in undoing part of the damage to which the Scotts Peak Dam itself contributed must not be allowed, if the risk of further damage is to be avoided.

The scientific value of the Lake Pedder geomorphology therefore remains intact. The aesthetic quality of the plains and lowermost slopes surrounding Lake Pedder will be less than it was for a while. The scars along the impoundment perimeter while being initially livid are relatively low, and will be largely masked or distant in the field of view across the lake to the mountains westward. From Pedder itself most will be largely inevident even in the short term. Even if a generation should pass before the worst of the scars are healed, that is a short span of time if protection of the environment, or in this case its restoration, is truly aimed at the benefit of future generations. Moreover, a single human generation is the blink of an eye compared to the time frame over which Lake Pedder has evolved, and the impact of three or four decades of ill - considered impoundment is of little consequence. But the present generation may reasonably expect that, almost from day one, many of the best loved scenes of Lake Pedder, Max Angus's vast bowl of light, will again be on view. Many of the photographic images that brought Lake Pedder to thousands, and attracted thousands to Lake Pedder - the rippled sands and burgundy waters, the beach cusps, the towering mountains reflected in tranquil lake waters, the Wagnerian cloudscapes and pink quartzite sands cast with the early morning light - will be captured again, pretty much from day one.

## ACKNOWLEDGEMENTS

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